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An electro-mechanical acoustic imaging scanner assembly.

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AN ELECTRO-MECHANICAL ACOUSTIC IMAGING SCANNER ASSEMBLY

by

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THESIS

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An Electro-mechanical Acoustic Imaging Scanner Assembly

by

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ABSTRACT

The design of a combined electro-mechanical acoustic image scanning assembly is described. Various acoustic imaging system techniques have demonstrated an ability to form underwater images at distances greater than those obtained by optical means.

The scanning assembly utilizes a sixteen element linear transducer array mounted on the radius of an eight inch diameter circle at the focal plane of an acoustic lens. The line array is rotated at a constant speed of 400 RPM. Acoustic signals at 250 KHZ of approximately 26 db re 1 ubar at the transducers were sufficient to produce satisfactory detection.

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I. INTRODUCTION

Acoustic imaging techniques have been the subject of extensive investigation. A number of methods for converting acoustic pressure images have been presented and discussed in Refs. 1-3. Of these methods, the most promising ones appear to be those utilizing piezo-electric mosaic arrays at the image plane of an acoustic lens. Electrical potentials at a point in the mosaic array are proportional to acoustic pressure amplitudes at that point. The potentials are then scanned by some means to produce a real-time visual display of the pressure field.

The simplest method of scanning would appear to be an entirely mechanical scan; but mechanical complexity is formidable and practical scanning rates are too slow to be of value for real-time imaging.

For image scanning techniques utilizing electronic techniques only, the principal advantages and disadvantages have been:

<u>Advantages</u>

Rapid scanning rates

Sensitivity to relatively low signal strengths

Good image resolution

<u>Disadvantages</u>

High costs due to the large number of components

Complexity of electronic circuits required.

Similarly, advantages and disadvantages in image scanning techniques utilizing combined electro-mechanical techniques have been:

Advantages

Simplification of design

Reduction of costs

Disadvantages

Low mechanical scanning rates

Reduced sensitivity due to flow noise around moving components.

This report is concerned with the design of a combined electro-mechanical acoustic image scanning assembly. This design was intended to represent a compromise between the advantages and disadvantages of completely electronic scanning techniques and entirely mechanical scanning techniques. Specifically, the desired objectives were to increase mechanical scan rates without introducing excessive flow noise and excessive lowering of sensitivity levels, reduce costs and complexity of design (mechanical and electronic), and maintain good range capability. The resultant design was to have an image resolution comparable to that of systems utilizing electronic scanning techniques.

In Ref. 3, Larkin developed a solid-state ultrasonic image converter module which could be duplicated in large number and combined to form a mosaic transducer array. This image converter was to be utilized in conjunction with a liquid-filled biconvex acoustic lens investigated by Roudebush in Ref. 4. A 32 x 32 array would have consisted

of 64 modules, each module costing about $250, or a total of $16,000.

The scanning assembly design of this report utilizes only one of Larkin's modules, a sixteen element linear transducer array, mounted on the radius of a circle at the focal plane of an acoustic lens. The transducer line array is rotated at a constant speed sweeping out a circle perpendicular to the axis of the acoustic lens. The rotational speed is low enough so that electronic scanning radially of the transducer line array is much faster than rotational scanning; however, rotational scanning is accomplished rapidly enough to prevent flicker in the long-persistence CRT presentation. Since only one of the sixteen channel printed circuit board assemblies developed by Larkin must be utilized, this reduces the electronic components required and reduces the power supply necessary to energize the electronic circuits. The resolution is effectively increased to approximately the resolution of a 32 x 32 array, depending on rotational speed and radial scan time. Image resolution may be increased further by decreasing radial scan time and/or rotational speed up to the limit imposed by transducer element size. The process of relatively rapid scanning of the radius of a circle while the radius is slowly swept around the circle is analogous to the scanning process used in a PPI radar presentation, except that rotational speed is much higher than that normally associated with radar antenna systems, and the display is in the plane perpendicular to the direction of sound propagation.

The scope of this report was limited to testing the feasibility of this design. Consequently, design testing was limited to:

(1) acoustic signal detection and amplification through one image converter channel

(2) transmission of the converted signal from rotating to stationary components without use of slip rings

(3) generation and transmission of synchronizing signals necessary to determine the position of a transducer element in the scanned circular plane

(4) successful operation of the mechanical and electrical components of the assembly

(5) determination of flow noise and mechanically induced noise at the design rotational speed.

II. DESIGN CONSIDERATIONS

A. GENERAL

The scanning assembly was to meet the requirements for a study, portable, low-input-power device. It was further designed either for mounting to a stationary platform (The platform is to provide the assembly with an azimuthal training capability.) or for handling by a diver. Additionally, its power supply for the Scanner Drive and Instrumentation Unit was to be readily available on board ship, i.e., 120 volt AC single or three phase power. The assembly was to be a purely passive device requiring target illumination by a separate transducer.

B. FREQUENCY

The assembly was designed to operate at a sound frequency of 250 KHZ with an approximate wavelength of six millimeters in seawater. This frequency is high enough to provide sufficient image resolution for targets of interest (swimmers, mines, fish, etc.), yet low enough considering attenuation by the seawater medium to return distinguishable target echoes at ranges out to approximately one hundred meters.

C. RANGE REQUIREMENTS

One hundred meters range was accepted nominally as a satisfactory range for either a hull-mounted assembly or a portable diver-handled assembly. This scanner assembly design did not include an image ranging capability, but this may easily be done with an adjustable time gating device.

D. SCANNER UNIT ROTATIONAL SPEED

A rotational speed of 600 RPM was selected as a compromise between turbulent flow noise and display flicker. At this speed, ten images per second are produced, which is sufficient to prevent flicker on a CRT with minimal scope persistency. The speed is also low enough so that viscous fluid drag on the rotating Image Converter Sub-unit is relatively low. The low speed also reduces stresses on internally mounted transducer and electronic elements. Bearing requirements are also reduced at this relatively low speed. The level and spectrum of flow noise at this speed was unknown, and was one of the main items of data to be obtained.

E. SCANNER UNIT

The Scanner Unit consists of two sub-units. They are the Outer Housing and Main Bearing Sub-unit (Stationary), and the Scanner Image Converter Sub-unit (Rotating). The two sub-units are shown in Figure 2. The Scanner Image Converter Sub-unit is shown disassembled in Figures 3-5.

1. Outer Housing and Main Bearing Sub-unit (Stationary)

This sub-unit was designed to provide:

(a) a stationary chassis to be used for adapting the Scanner Unit to an outside platform if desired, or for ease of personnel handling without exposure to rotating components

(b) a stationary outer housing to protect the Image Converter Sub-unit

(c) a heat transfer surface to the seawater medium for dissipation of internally generated bearing and viscous drag heat

(d) a bearing surface to carry the weight of the rotating Image Converter Sub-unit

(e) a container for the fluid used to lubricate the main bearing with provisions for filling and draining

(f) a hydraulic shaft seal to separate the bearing lubricant from the seawater medium

(g) a circular diaphragm of mylar to allow sound transmission through to the Image Converter (the diaphragm allows equalization of hydrostatic pressures between seawater and bearing lubricant and also forces the diaphragm on the Image Converter against the transducer elements' active faces).

A journal bearing design was selected for the main bearing. This type bearing causes the rotating journal to ride on a thin wedge of lubricating fluid. This design was considered preferable to a ball or roller bearing, since ball or roller bearings could produce noise to interfere with the acoustic signal. Buoyancy forces existed on the Image Converter Sub-unit since it is filled internally with air at atmospheric pressure. The resulting buoyancy imposed a bearing load of approximately ten pounds at a distance of 5.6 inches from the bearing center. The bearing was made as long as possible to reduce the distance from bearing center to load center, and also to reduce displacement between the rotating shaft center axis and bearing center axis. The bearing has a thrust bearing face at one end for bearing against a thrust collar machined on the Image Converter shaft. This prevents the capacitor disk at the end of the rotating shaft from contacting the stationary capacitor disk mounted parallel to the rotating disk. The journal bearing was designed for forced lubricant flow to provide increased dissipation of bearing heat.

Transformer oil was selected as the bearing lubrication fluid. Transformer oil is a satisfactory lubricant for low-temperature, low-speed bearing conditions; it has a relatively low viscosity resulting in reduced drag; its dielectric property is desirable in the event of leakage into the Image Converter; and it has a specific acoustic impedance very nearly equal to the specific acoustic impedance of seawater.

2. <u>Scanner Image Converter Sub-unit (Rotating)</u>

The Scanner Image Converter Sub-unit was designed to perform the following functions:

(a) provide a watertight enclosure for electronic components while simultaneously allowing the incoming acoustic signal to pass through to the transducer element active faces with minimum signal power loss

(b) provide a mounting for the transducer elements capable of holding the elements in place against hydrostatic pressure and centripetal forces

(c) prevent formation of standing acoustic waves between the Image Converter front face and the acoustic lens

(d) electronically scan, rectify, and amplify the sixteen transducer element signals.

(e) generate a synchronizing pulse for external use at the beginning of each electronic scan

(f) transmit the image information signal and scanning synchronizing pulse from the rotating Image Converter to an external stationary component for processing

(g) provide mountings for power supplies and electronic components

(h) provide on-off switching for power supplies at a point external to the watertight enclosure.

A lead-zirconate-titanate ceramic composition was used for the transducer array. Each segment is cut to a half wavelength at 250 KHZ (6 mm.) in the direction of the incoming wave. The square segment faces perpendicular to the incoming wave each have an area of 9 cm^2. Four of these segments in a 2 x 2 mosaic are wired in parallel and form one of the sixteen transducer elements in the linear array. Utilization of a half wavelength transducer segment requires clamping of the segment 3 mm. back from the faces perpendicular to the incoming wave. The mounting was to be made thin enough so that longitudinal waves in the segments would suffer minimum damping, yet wide enough to provide sufficient strength against the shearing stresses imposed on the mounting faces from hydrostatic pressure and centripetal forces. The transducer array mounting arrangement is shown in Figure 6.

The remainder of the Image Converter front face exclusive of the transducer array and its mounting strips was to be covered with a sound absorbing material which would limit the reflection of the incoming wave back to the acoustic lens.

The entire front face of the Image Converter was to be covered with a diaphragm which would be seated firmly against the transducer faces by hydrostatic pressure and allow passage of the acoustic wave with a minimum of attenuation.

The solid-state electronic image converter shift register was to provide a one millisecond total scan time

across the sixteen transducer elements. The pulse initiating a scan was to be transmitted along with the image converter output signal as the external synchronizing pulse.

Since the output of each transducer element was to be rectified, the image converter information signal would be a continuous sequence of sixteen varying positive DC levels. The highest first harmonic frequency of this signal would occur with every other transducer element at a zero level. This would generate a first harmonic frequency of 8 KHZ.

A frequency-modulated solid-state transmitter was selected to transmit the image converter information signal from the rotating Image Converter Sub-unit to an external stationary component. The transmitter signal was to be transmitted across a plane two-plate capacitor. One plate of the capacitor was to be rotating with the other plate stationary. The plates were to be circular disks. The capacitor impedance with designed to be 50 ohms at the 95 MHZ carrier frequency selected for the FM transmitter. Utilizing a four inch diameter circular disk plate would require a plate spacing of 0.084 inches. This would result in a capacitance of 33.6 picofarads.

A schematic diagram of the Scanner Image Converter circuitry is shown in Figure 7.

F. SCANNER DRIVE AND INSTRUMENTATION UNIT

The Scanner Drive and Instrumentation Unit consists of a Motor and Variable Speed Drive Sub-unit, an Instrumentation

Sub-unit, two auxiliary shaft bearings, and a unit housing. Details of the Scanner Drive and Instrumentation Unit are shown in Figure 8.

1. Motor and Variable Speed Drive Sub-unit

The Motor and Variable Speed Drive Sub-unit was designed to perform the following functions:

(a) provide sufficient motive power to drive the Scanner Image Converter Sub-unit at variable speeds up to 600 RPM

(b) reduce drive motor speed through a variable speed hydraulic transmission and pulley belt drive to speeds of 600 RPM and lower.

2. Instrumentation Sub-unit

The Instrumentation Sub-unit was designed to perform the following functions:

(a) generate an external bearing synchronizing pulse at the completion of each rotation of the Image Converter Sub-unit

(b) generate a signal indicating Image Converter Sub-unit rotational speed

(c) provide connections for transmitting the Scanner Unit information signal and external scan synchronizing pulse, external bearing synchronizing pulse, and rotational speed indication signal to a remote point outside the scanner assembly.

3. Auxiliary Bearings

The two auxiliary bearings were designed to supplement the function of the main bearing in the Outer Housing and Main Bearing Sub-unit. A roller bearing design was chosen since roller bearings are acoustically quieter than ball bearings and are self-lubricating. Location of the auxiliary bearings in the Scanner Drive and Instrumentation Unit was considered far enough away from the acoustic

transducer to avoid interference with the incoming acoustic image signal.

4. Unit Housing

The Unit Housing was designed to perform the following functions:

(a) provide a watertight enclosure for the Motor and Variable Speed Drive and Instrumentation Sub-units

(b) provide cooling air to the drive motor

(c) provide for passage of all cabling to a remote point outside the scanner assembly

(d) provide vibration damping mountings for the Motor and Variable Speed Drive Sub-unit

(e) provide a mounting for the auxiliary bearings and instrumentation components

(f) provide adjustable structure members for support of the Outer Housing and Main Bearing Sub-unit

(g) provide a means of lifting the entire scanner assembly with an overhead crane.

III. DESIGN IMPLEMENTATION AND RESULTANT PROBLEMS

A. GENERAL

The Scanner Image Converter Sub-unit was successfully driven by a 120 volt AC, 60 HZ, single phase drive motor. This is a readily available power supply on board U. S. Navy ships.

The Scanner Unit Outer Housing and the Scanner Image Converter watertight enclosure are large diameter stainless steel tubing. The Scanner Drive and Instrumentation Unit housing is 3/16 inch sheet aluminum with base and side plates welded and with a gasketed closure top plate. The bearing material in the shaft main bearing is brass. All other strength and mounting members are aluminum. These materials were chosen for their mechanical strength, corrosion resistance, and non-magnetic properties.

The entire scanner assembly weighs 219 pounds in air and has a positive buoyancy of approximately 196 pounds submerged for acceptable portability in air or submerged with weights.

Future designs should utilize a housing of reduced volume for the Scanner Drive and Instrumentation Unit. This would reduce the weight in air, result in nearly neutral buoyancy when submerged, and reduce the area subjected to hydrostatic pressure.

The completely assembled Acoustic Image Scanner Assembly is shown in Figure 1 without the Scanner Drive and Instrumentation Unit housing top plate closure in place.

B. FREQUENCY AND RANGE

The single image conversion channel tested required a sound pressure level of 26.5 db re 1 ubar at the front face of the Scanner Unit to produce an acceptable output level at the output of an FM receiver discriminator located external to the scanner assembly. This sound pressure level requirement results from the summation of 6.5 db re 1 ubar required at the transducer element faces plus an additional loss of approximately 20 db resulting from flow noise and transmission through the diaphragms. For a one hundred meter range capability, this would require a source level of approximately 82.2 db re 1 ubar. This source level was calculated considering the following data:

(1) an acoustic lens gain of approximately 20 db

(2) a target strength of approximately -12 db (one meter diameter spherical target)

(3) a two-way spherical divergence loss of 80 db

(4) a two-way absorption loss of 4.68 db in seawater at 5°C

(5) a source with a plane radiating surface of diameter 3.4 cm. with transmitting directivity index of 25 db.

C. SCANNER UNIT ROTATIONAL SPEED

Viscous drag calculations indicated an approximate power requirement of 1/10 horsepower maximum assuming laminar flow. Since turbulent flow was likely to occur at high rotational speeds as a result of a high Reynolds Number and imperfections in surfaces and geometry, a one-half horsepower drive motor was utilized. The motor was

designed to produce one-half horsepower at a rated current of 6.5 amperes at a 0.54 power factor. At a Scanner Image Converter speed of 600 RPM, the motor utilized 6.3 amperes. Dissipation of internal motor heat at this operating condition was considered marginally satisfactory utilizing natural air circulation through duct connections to the interior of the Scanner Drive and Instrumentation Unit housing. The Scanner Image Converter speed was then lowered to 400 RPM, reducing drive motor current to 5.7 amperes. Heat dissipation was considered slightly improved at this speed. Further attempts to reduce motor current included utilizing water as a lubricant for the main bearing in the Scanner Unit, and, finally, dissolving polyethylene oxide in the lubricating water to a concentration of 200 parts per million by weight to reduce turbulent flow effects. The water lubrication resulted in a motor current of 5.5 amperes, and the addition of polyethylene oxide further reduced the motor current to 5.1 amperes. Heat dissipation at 5.1 amperes was considered satisfactory after a four hour motor run time. The reduced speed of 400 RPM was considered to be a high enough rotational speed to prevent flicker in a CRT scope with adjustable persistency (storage scope).

Since the drive motor utilized single phase power, it was found necessary to start the motor with the variable speed transmission set for zero output speed to allow the drive motor to reach a speed necessary for the motor control circuitry to open the starting winding circuit. When

starting the motor with the variable speed transmission set for 400 RPM, the starting winding was not being deenergized and the motor quickly reached unsatisfactory temperatures. This required the installation of a remote control rod assembly for varying the speed transmission output so that the drive motor could be started with no load.

The one-half horsepower motor was replaced with a one horsepower motor which was designed to operate at a rated current of 13.5 amperes with a 0.48 power factor. This motor utilized 8.7 amperes to drive the Image Converter Sub-unit at 400 RPM. Additionally, the motor was powerful enough to start with the variable speed transmission set to drive the Image Converter Sub-unit at 400 RPM and eliminated the necessity for the remote control rod assembly for starting. However, it is still useful for flow noise versus speed determination. This motor was of a newer design and heat dissipation at this amperage was satisfactory.

Future designs should utilize a watertight submersible motor. Motor cooling by heat exchange across the motor casing to seawater would eliminate heat dissipation problems. Once the optimum Image Converter speed is determined, direct pulley drive from the submersible motor to the rotating shaft of the Image Converter should be utilized. This will reduce assembly weight and size of the Scanner Drive and Instrumentation Unit and housing, thereby reducing hydrostatic stress area of the unit housing.

D. SCANNER UNIT

1. Outer Housing and Main Bearing Sub-unit

All components of this sub-unit performed design functions satisfactorily.

The main bearing design included provisions for port holes through the bearing sleeve and bearing retainer walls at points near the opposite end of the bearing from its thrust face. The shaft thrust collar tends to "pump" lubricant out of the bearing as a combined result of viscous drag and "centrifugal" forces when the shaft is rotating. The "pumped" lubricant is replaced by intake flow through the port holes at the other end of the bearing. These effects result in forced lubricant flow to the main bearing. The main bearing operated satisfactorily using transformer oil or fresh water as lubricant with no sensible heat by touch on the Outer Housing at a point in contact with the main bearing.

2. Scanner Image Converter Sub-unit

All components of this sub-unit performed design functions satisfactorily with minor modifications to the original design.

It became necessary to utilize 1/16 vice 1/32 inch butyl rubber gaskets to maintain watertight integrity.

The mounting assembly for the transducer array utilized epoxy adhesive between plexiglass mounting strips and the transducer elements. The width of the adhesive application was approximately 1/32 inch. This provided necessary strength for the hydrostatic and centripetal

stresses and minimally damped the longitudinal waves in the transducer segments.

Surgical dam rubber was originally selected as the front face diaphragm covering. Surgical dam material provided low signal attenuation and was flexible enough to seat firmly against the transducer faces. However, the rubber exhibited a marked tendency to tear when stretching it onto its mounting screws. A mylar diaphragm was then utilized since it could be mounted without tearing as easily as the rubber. The mylar exhibited satisfactory attenuation properties. The mylar, however, was not as flexible as the rubber. It then became necessary to raise the transducer faces 0.004 inches above the cork on the Image Converter front face. The combination of raised transducer faces and hydrostatic pressure against the diaphragm ensured a firm seating of the mylar against the transducer faces.

A 0.250 inches covering of Armstrong MIL-G-6183 cork was placed over the remainder of the Image Converter front face exclusive of the transducer faces and mounting strips. The cork in combination with its aluminum backing plate reduced the intensity of the incoming wave by a factor of four upon reflection of the incoming wave. This was considered a high enough attenuation so that the reflected wave would not interfere significantly with incoming waves at the acoustic lens.

A single channel circuit shown in Figure 7 was used for image conversion at the output of the transducer element tested. The major difference between this circuit and the

one developed by Larkin is that one additional stage of preamplification is utilized in the amplifier-detection circuitry in order that system noise levels could be evaluated. An emitter follower stage was placed between the output of the solid-state image converter and the input to the FM transmitter stage to provide a proper impedance match between the two circuits.

The FM transmitter shown in Figure 7 utilized a voltage controlled oscillator (VCO) to modulate a carrier frequency of 88 MHZ. The transmitter output was coupled into 50 ohm coaxial cable. The cable was led through the center of the rotating shaft and connected to the rotating capacitor disk in the Scanner Drive and Instrumentation Unit housing.

E. SCANNER DRIVE AND INSTRUMENTATION UNIT

1. Motor and Variable Speed Drive Sub-unit

All components of this sub-unit performed design functions satisfactorily with minor modifications of the original design.

The one-half horsepower motor was replaced with a one horsepower motor as previously reported.

The pulley and V-belt original design utilized a two to one speed stepdown from the variable speed transmission to the shaft of the Image Converter. The design was changed to a four to one stepdown so that the variable speed transmission operated at a more efficient speed.

2. Instrumentation Sub-unit

All components of this sub-unit performed design functions satisfactorily.

The rotational speed indicator utilized a DC tachometer generator (2.6 VDC per 1000 RPM). The tachometer generator was gear driven from the Image Converter shaft. The gear ratio was two to one with the tachometer generator at the higher speed. This speed doubling was necessary to reduce the size of the gear wheel driving the tachometer generator.

A bar magnet was mounted on the radius of the tachometer generator gear wheel. The magnet was utilized to close a reed switch once for each rotation of the tachometer generator gear wheel. This generated two pulses for every rotation of the Image Converter. A multivibrator circuit shown in the schematic diagram of Figure 9 was then utilized to pass every other pulse corresponding to each rotation of the Image Converter.

The rotating disk at the end of the Image Converter shaft and the stationary disk mounted opposite it had a measured capacitance of 20.5 picofarads with a 0.080 inches spacing between the disks. The Image Converter FM transmitter tuned to an actual carrier frequency of 88 MHZ. This resulted in an impedance of 88.5 ohms. The disks were machined to have less than 0.001 inches relative motion between disks measured in a shaft axial direction. This eliminated any significant generation of a 400 hertz or higher harmonic noise in the information signal transmission.

3. Auxiliary Bearings

The two auxiliary bearings performed their design function satisfactorily.

4. Unit Housing

The unit housing performed design functions satisfactorily with minor modifications.

Natural air circulation duct connections were enlarged from three inches diameter to six inches diameter to provide adequate dissipation of drive motor heat.

The original design utilized strut extensions from the unit housing to carry the weight of the Scanner Outer Housing and Main Bearing Sub-unit. Since this weight varied depending on whether the scanner assembly was being operated in air or submerged, shaft alignment in the bearings and hydraulic shaft seals which had been satisfactory in air was not satisfactory in water, and vice versa. This problem was eliminated by installing adjustable turnbuckles in the guy wires supporting the strut extensions.

A teflon spacer was installed between the pulley wheel on the Image Converter shaft and the hydraulic shaft seal at the unit housing wall. This prevented shaft thrust in a direction toward the front face of the Image Converter in the event the scanner assembly is subjected to a down angle from the horizontal. This condition would occur if, for example, a diver-handled assembly was trained downward.

F. HYDROSTATIC PRESSURE SEAL TESTING

Hydrostatic pressure closures were tested only to a depth of approximately three feet of water pressure differential. Testing to greater pressures was not considered appropriate until future design changes previously mentioned in this report are implemented. The aforementioned design changes should improve the depth capability of this assembly. Additionally, it may become necessary to incorporate flooding of the watertight enclosure inside the Image Converter Subunit with a dielectric fluid. This would result in pressure equalization across the transducer array and a corresponding reduction in stresses on the transducer array mounting.

IV. CONCLUSIONS

A. GENERAL

It has been demonstrated that the combined electro-mechanical acoustic image scanning assembly could be operated at rapid scanning rates with simplicity of design, reduced costs, and enough sensitivity to convert images at ranges up to 100 meters at a frequency of 250 KHZ.

B. ELECTRONIC COMPONENTS

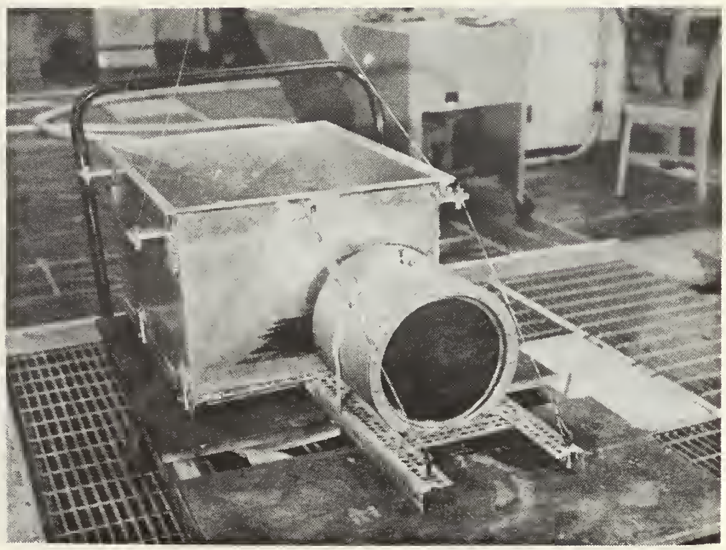
Acoustic signal sound pressure levels of approximately 26 db re 1 ubar at the transducers were sufficient to produce satisfactory acoustic signal detection, amplification, and transmission to a point external to the scanner assembly. Additionally, synchronizing signal information necessary for the display of the acoustic signal on a PPI scope presentation was successfully generated.

C. MECHANICAL COMPONENTS

Mechanical components were successfully operated on a continuous basis. Flow noise and induced mechanical noise at frequencies of interest lowered the scanner assembly sensitivity by approximately 20 db re 1 ubar at a rotational speed of 400 RPM.

FIGURE 1a

Overall view of Scanner Assembly Less Top Plate on Scanner Drive and Instrumentation Unit



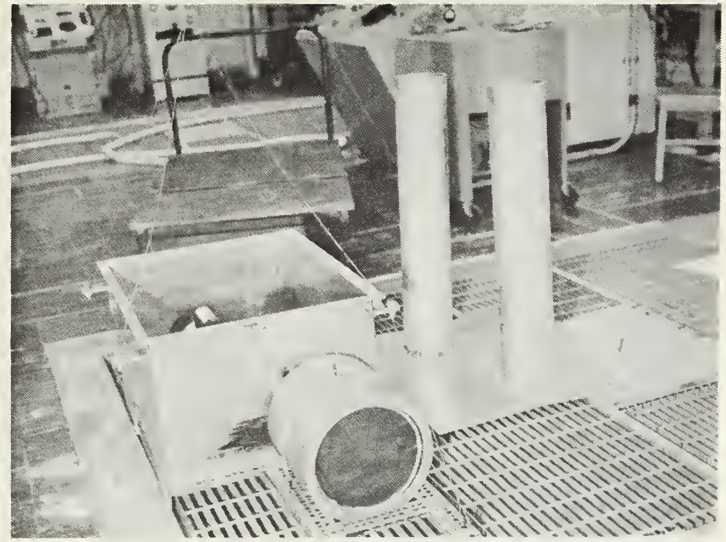


FIGURE 1b

Overall view of Scanner Assembly Showing Top Plate of Scanner Drive and Instrumentation Unit Alongside Assembly

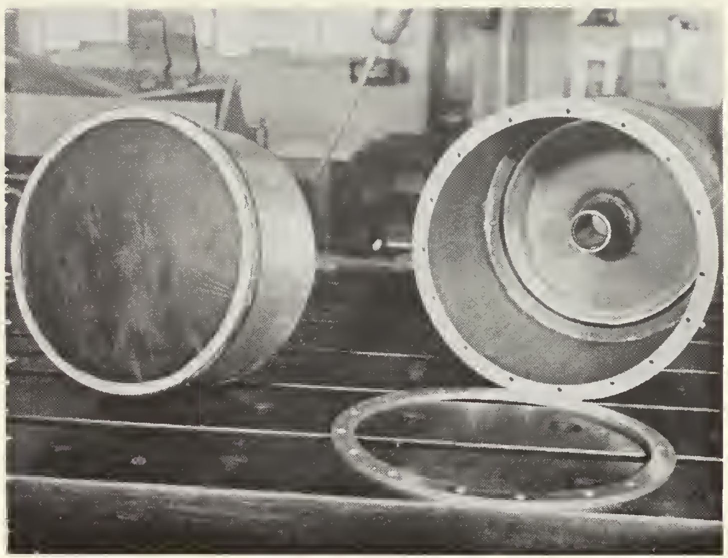


FIGURE 2

Scanner Drive Unit with Sub-units
Disassembled (front face view)

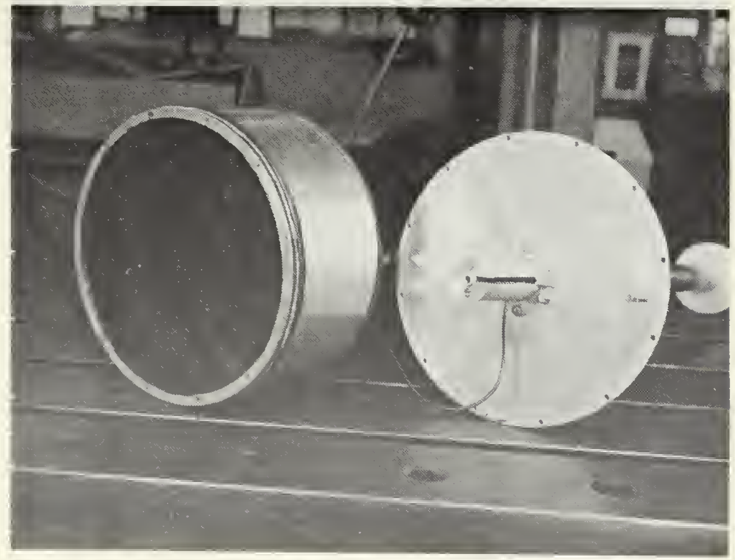


FIGURE 3

Scanner Image Converter Sub-unit
Disassembled (front face view)

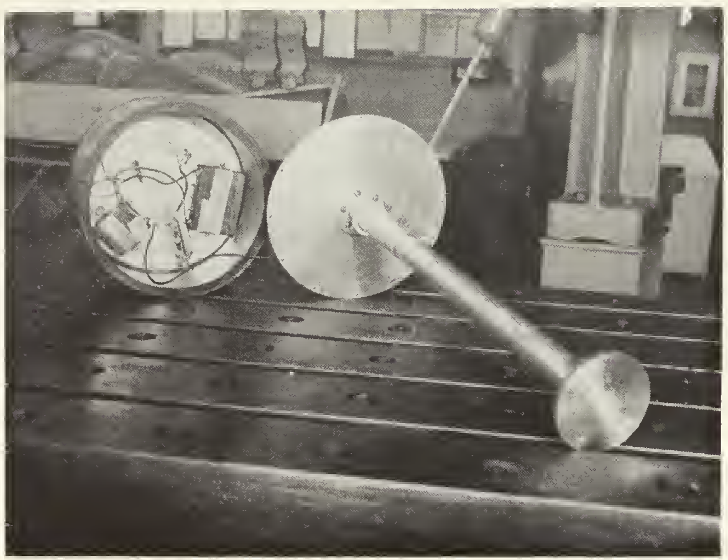


FIGURE 4

Scanner Image Converter Sub-unit
Disassembled (rear view)

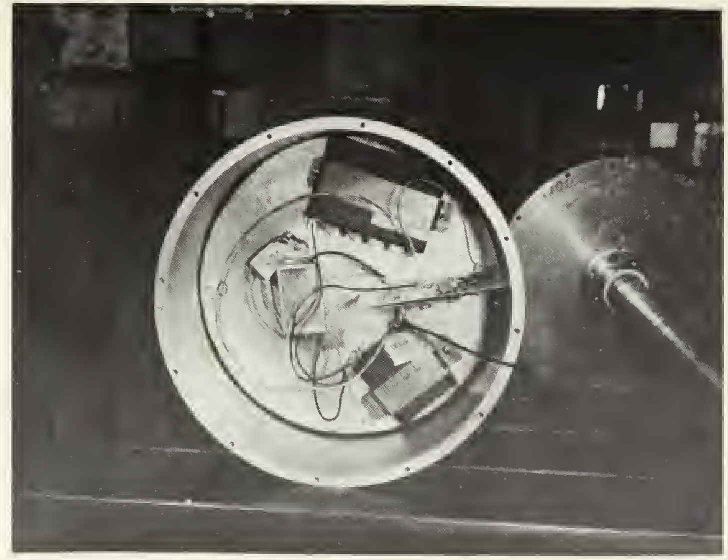
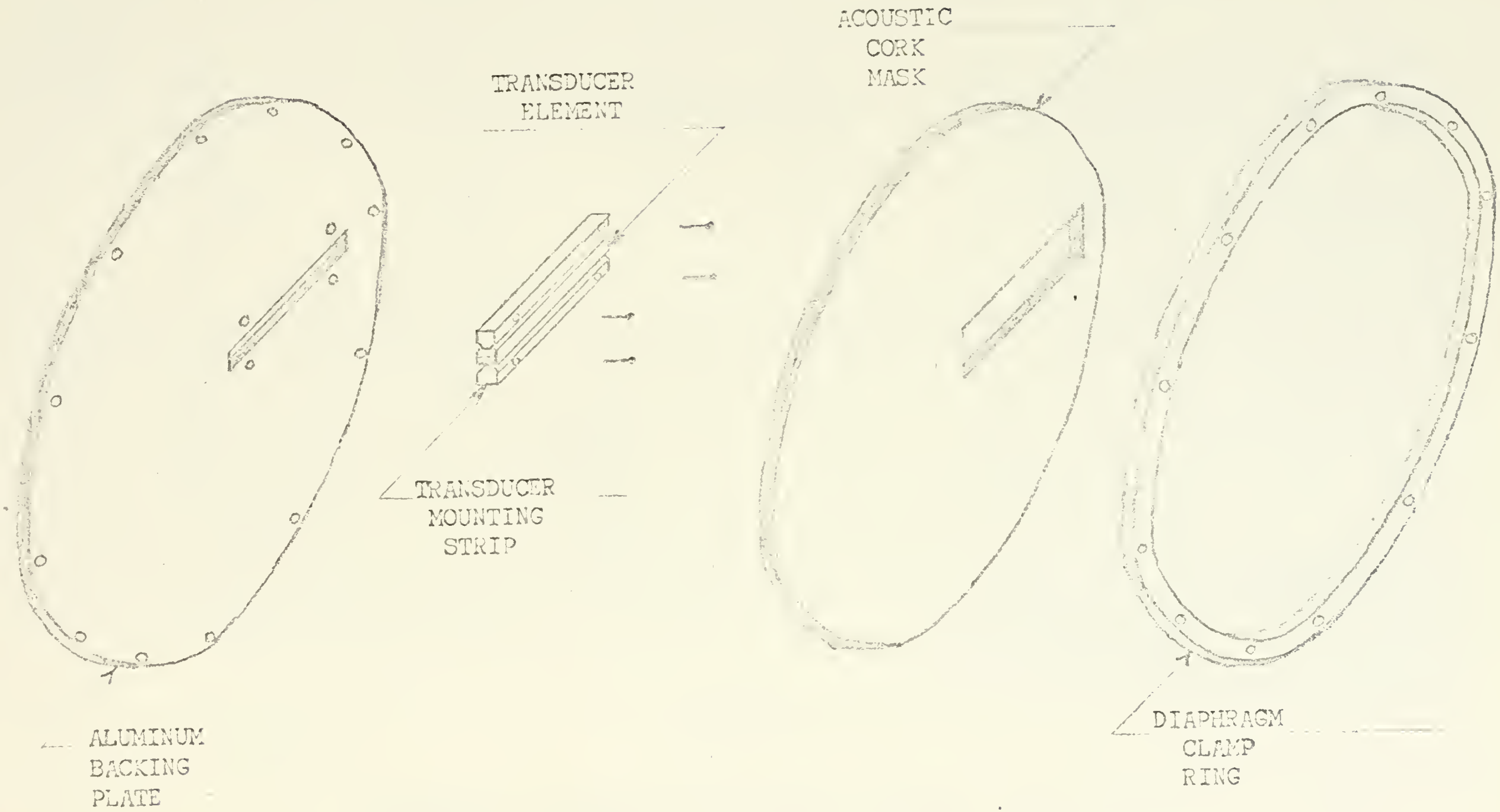


FIGURE 5

Closeup of Scanner Image Converter
Internal Components

FIGURE 6



Scanner Image Converter Front Face
Showing Details of Transducer Mounting Arrangement

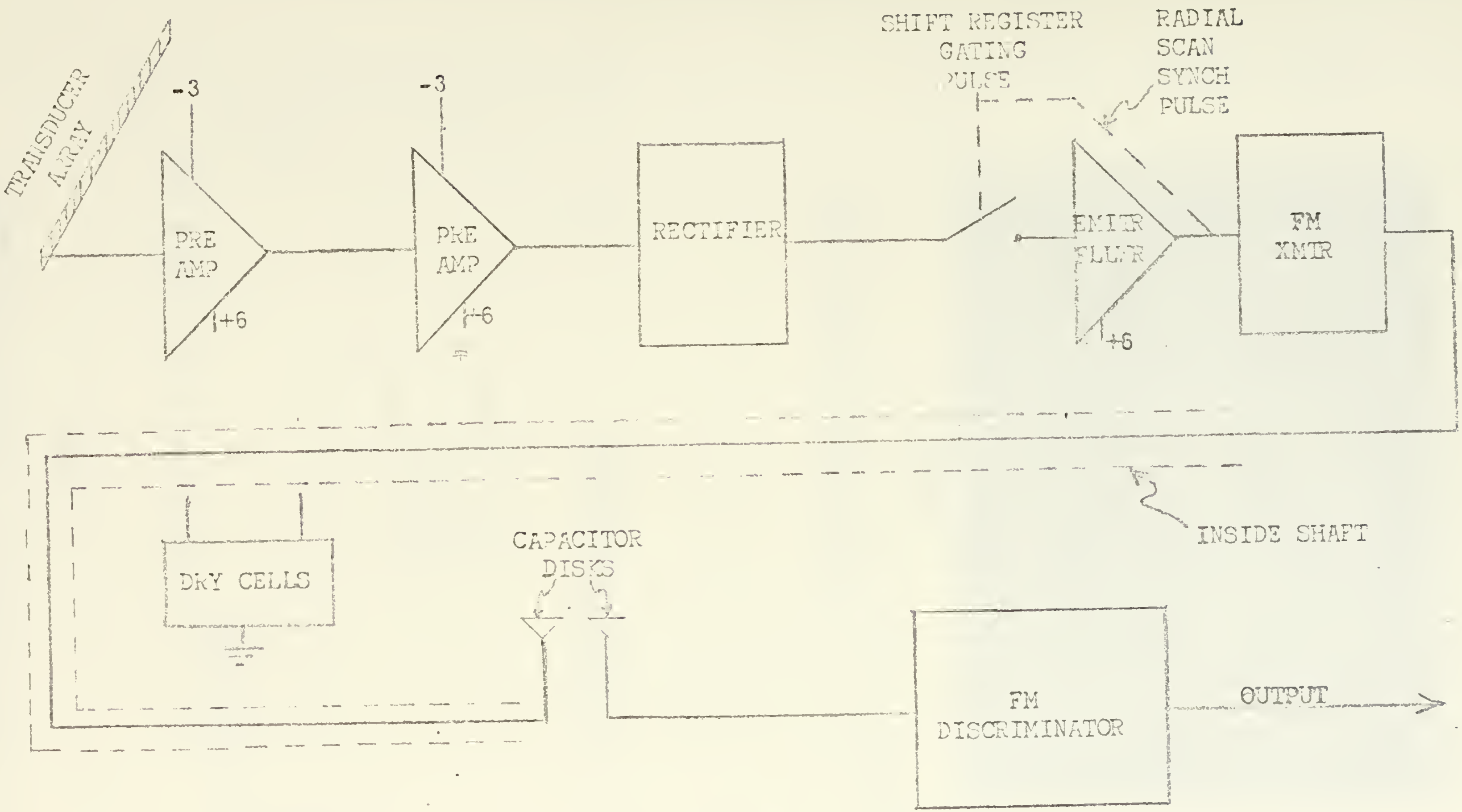


FIGURE 7

Schematic Diagram of Acoustic Signal Conversion
and Transmitting Circuitry

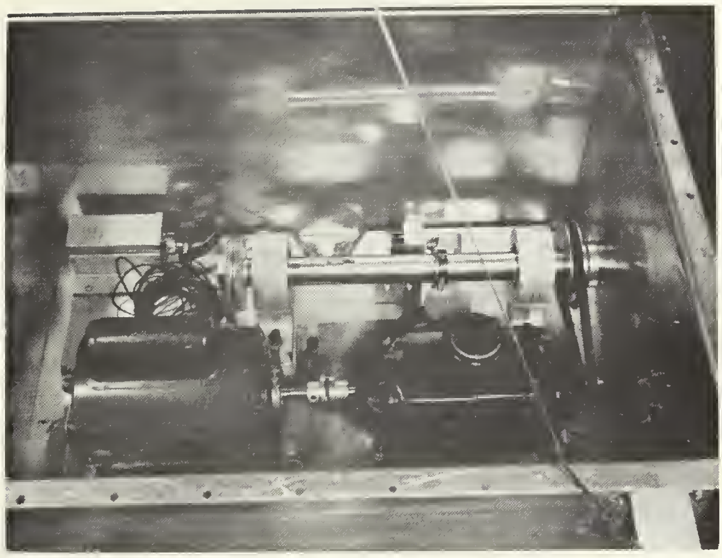


FIGURE 8

Closeup of Scanner Drive and Instrumentation Unit Internal Components

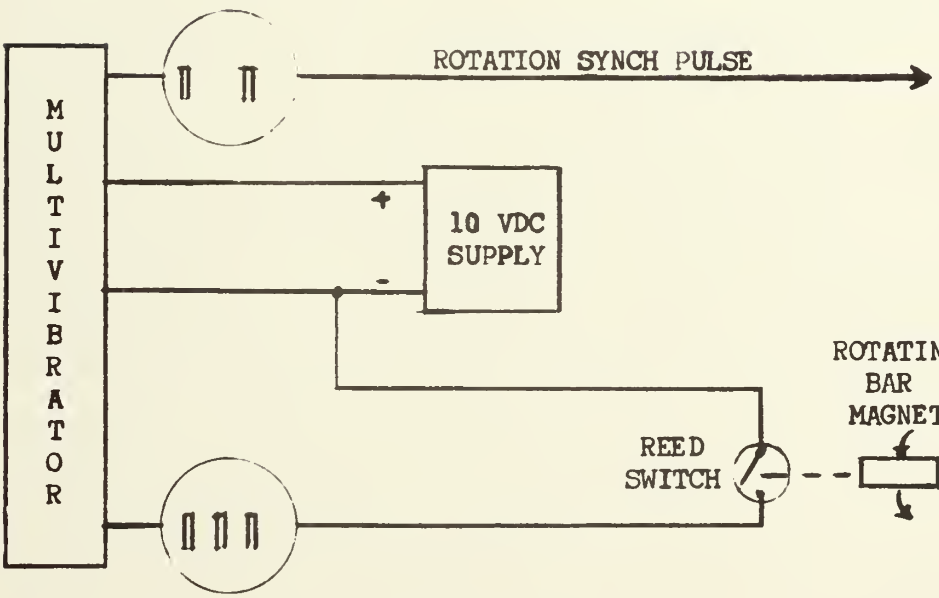


FIGURE 9

Schematic Diagram of Circuitry for Generating Rotation Synchronizing Signal

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13. ABSTRACT

The design of a combined electro-mechanical acoustic image scanning assembly is described. Various acoustic imaging system techniques have demonstrated an ability to form underwater images at distances greater than those obtained by optical means.

The scanning assembly utilizes a sixteen element linear transducer array mounted on the radius of an eight inch diameter circle at the focal plane of an acoustic lens. The line array is rotated at a constant speed of 400 RPM. Acoustic signals at 250 KHZ of approximately 26 db re 1 ubar at the transducers were sufficient to produce satisfactory detection.

14 KEY WORDS	LINK A		LINK B		LINK C	
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